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HARVEIAN ORATION

DELIVERED AT THE

ROYAL COLLEGE OF PHYSICIANS,

OCTOBER 18TH, 1886,

BY

F. W. PAVY, M.D., F.R.S.

Bacteria



LONDON:

J. & A. CHURCHILL, NEW BURLINGTON STREET.

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HARRISON AND SONS,
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TO

SIR WILLIAM JENNER, BART., K.C.B.

M.D., F.R.S., D.C.L., LL.D.,

President

OF THE

Royal College of Physicians of London,

THIS ORATION,

As a Tribute of Esteem,

IS

DEDICATED.

“Homo, naturæ minister et interpret, tantum facit et intelligit, quantum de ordine naturæ opere vel mente observaverit; nec amplius novit aut potest.”

. . . . “dati effectus in quovis subjecto causas nosse, intentio est humanæ scientiæ :”

*Aphorismi et Consilia, de auxiliis mentis, et accensione
luminis naturalis, FRANCISCI BACONI.*

THE
HARVEIAN ORATION.
1886.



MR. PRESIDENT,
COLLEAGUES, AND GENTLEMEN,—

My instructions are explicit. Once every year, said Harvey, in the deed of conveyance of his patrimonial estate as a gift to the College, some one shall make an oration publickly in the College, “wherein shall be a commemoration of all the benefactors of the said College by name, and what in particular they have done for the benefit of the said College, with an exhortation to others to imitate those Benefactors and to contribute their endeavours for the advancement of the Society, according to the example of those Benefactors,

and with an exhortation to the Fellows and Members of the said College to search and study out the Secrets of Nature by way of experiment."

Such are the directions, framed nearly two-and-a-half centuries ago, which bring us together here to-day. Himself a munificent benefactor in various ways to the College, and an ardent explorer of nature, Harvey desired that others should be incited to follow in the path that he had trodden. He was not content to quit life without taking steps to encourage others in succeeding generations to pursue the objects which he so strove by his own endeavours to promote. By this oration which he established, and which, notwithstanding the lapse of time that has occurred, may be said, I think, still to elicit as much reverential consideration within the College as at any period, an annual reminder is afforded that keeps his desire alive before us.

Honoured by the invitation of our President this year to deliver the oration, I am here to perform the task. Whilst highly appreciating the mark of distinction conferred, I must however, confess,

looking at the able hands through which the duty of orator has passed, and the eminence in the profession of many present, that I do not approach the undertaking without a deep sense of the responsibility attaching to it.

The first portion of the duty which has been marked out in such precise terms by the founder of this oration to be performed is to commemorate the benefactions that have fallen into the possession of the College since the last oration was delivered. It is gratifying to me to feel that I do not come empty-handed for the occasion before you.

A new benefaction, which promises to be as useful as it is munificent, has to be recorded, and it belongs to me to mention the manner in which the College has decided to dispose of a recently acquired increased income derivable from one of its ancient benefactions. My immediate predecessor alluded to the augmentation which the income from the endowment for the Croonian lectureship has recently undergone. Dr. Croone, a Fellow of our College in the seventeenth century, left behind him

a plan for the establishment of a lectureship, but made no provision in his will for its support. His widow, who afterwards married Sir Edwin Sadlier, bequeathed property in the City of London for carrying out the plan that had been thus fruitlessly framed.

It was a gracious act on the part of this lady, and one which showed a noble reverence for her first husband's wishes, to take upon herself in such a manner to give effect to his intention. Through the expiration of a ninety-nine years' building lease the College has come into possession of an income from the Lady Sadlier bequest which raises the amount available for the Croonian lectureship from £10 to £200 per annum. Those present are aware that the consideration of how to turn this twenty-fold increase to best account to meet the objects of the Trust, and at the same time secure the advancement of knowledge in a direction likely to produce beneficial results, has anxiously engaged the attention of the Fellows. After passing through the hands of a committee, the subject was discussed at three College meetings, at the last of which, the

comitia held in June, a resolution expressed in the following terms was passed :—

“That there shall be one or more Croonian lecturers appointed by the College, who shall be required to deliver lectures on one or more subjects in anatomy, physiology, and pathology, with a view to the prevention, control, and cure of disease ; and that the College shall devote the funds derived from the Croonian Trust (1) to the payment of such lecturer or lecturers, and (2) to the contribution of such sums as the College may think fit towards the promotion of scientific investigation on the subject of the lectures.”

Thus has the College determined to dispose of the increased income that has fallen into its hands through the chance influence that has been wrought by time upon the value of the endowment. The sum to be annually appropriated from the Croonian Trust is now of considerable magnitude, and let it be hoped that the fruit yielded by its application may equal in usefulness what I am sure it is desired by the College it should do. Should this be attained, the benefits issuing from the benefac-

tion will immeasurably surpass those that could have been anticipated either by Dr. Croone in planning his design for the lectureship, or Lady Sadlier, his noble-minded widow, in providing an endowment for giving to it a practical shape.

The new benefaction has come into the possession of the College since the commencement of the present year. Not quite recently, but at the same time not long ago, there was to be frequently seen at the College one who, though strikingly quiet and unostentatious in manner, made his presence strongly felt amongst us whenever matters were under consideration bearing on public health. Born and educated in Edinburgh, Gavin Milroy, to whom I refer, became a Fellow of this College in 1853. Never engaged in hospital or private practice, and his mind early drawn to the consideration of questions touching on the prevention of the extension of disease, he devoted himself to the hygienic part of our professional art and became an authority of high repute on social matters affecting health. In such estimation, indeed, was his knowledge held that he was

employed by Government for carrying out certain special inquiries, and afterwards was granted a life pension of £100 a year in recognition of the services he had rendered. He lived to the ripe age of eighty-one, and what I have said of his life bears upon his benefaction to the College. In his will he said: "I bequeath to the President and Council of the Royal College of Physicians in London for the time being the sum of £2,000 (being a sum of £1,743 which I received from the Colonial Office as remuneration for my services in 1871 and 1872 whilst engaged in my mission to the West Indies, with £257 which I have added thereto), for the purpose of founding and continuing a yearly lectureship of three or four lectures on state medicine and public hygiene, and upon trust to invest the same in the public funds, or in such other investment as they shall in their absolute discretion think fit, and upon trust to pay the income thereof to a lecturer to be appointed from time to time." In another part of his will he directed that the sum bequeathed should be paid free of legacy duty, and further gave the silver

inkstand which had been presented to him by the College in 1868 in acknowledgment of his services as Honorary Secretary to the Committee on Leprosy, and certain books specifically mentioned by him.

A thorough master in the branch of study to which he devoted himself, no one was in a better position than Dr. Milroy for suggesting the direction in which the attention of those who may hereafter be appointed to carry out his beneficent design may be most advantageously given ; and thoughtfully and, doubtless it will be found, most usefully he has left behind him an elaborate code of suggestions for the consideration of the Council of the College in its administration of the trust with which it has been charged. As a preface to these suggestions he remarks : " I would take leave to record some thoughts that have occurred to my mind concerning the subject-matters which, as it seems to me, might be most profitable for investigation at the present time, and possibly for some years to come. I am far from seeking to limit, or in any measure to impede, the free decision of

the Council in respect of the conduct and arrangement of the lectures themselves ; my only desire being how most usefully to promote the advancement of Medical Science along with the interests of philanthropic benevolence and of social welfare."

Could any wiser or more useful form of bequest than this of Dr. Milroy have been bestowed ? The College is no longer itself in need of the aid required in former times, but funds placed at its disposal for promoting the acquirement of knowledge constitute a benefaction that confers upon it the power of doing good in a manner standing most in harmony with the wants of the present age. Further, it may be said, the kind of knowledge sought to be advanced by the terms of the Milroy endowment is just that which is most ripe for encouragement at the present moment, and that also which holds a foremost rank in promise of benefit of a wide nature being conferred by its improvement.

I have ventured to consider that such a benefaction as this which it has devolved upon me to commemorate is the best kind of benefaction the

College could now receive. Probably Harvey had in his mind especially the encouragement of the bestowal of benefactions of a nature calculated in a more direct way to benefit the College. If we carry our thoughts—and looking at the position in which the College stands at the present time it requires a little effort to do so—I say, if we carry our thoughts to what the College was in Harvey's day, we realise that needs then existed which have now disappeared. We have no longer occasion to give ourselves concern about the corporate welfare of the College in the manner that was formerly called for. Founded “with a view to the improvement and more orderly exercise of the art of physic, and the repression of irregular, unlearned, and incompetent practitioners,” the College for a long time possessed but very meagre accommodation. A gift by our Founder and first President, Linacre, of the front portion of his private house, “comprising a parlour below and a chamber above, to be used as a council room and library,” constituted for many years the only local habitation belonging to the College—a modest beginning

indeed for the edifice in which we are now assembled. On the announcement towards the end of the sixteenth century by Dr. Caldwell and Lord Lumley of their intention to found a surgery lecture, and to endow it with £40 a year, the Fellows determined to appropriate £100 out of the common stock (and this was nearly all the money the College possessed) to enlarge the building and make it more ornamental and better suited for the meetings of their body and the celebration of the lectures. We next learn that just before Harvey entered upon his tenure of the Lumleian lectureship, contributions from its members and some others were forthcoming which enabled the College to take more suitable premises to which it removed. Subsequently, during the troubled times of the civil wars, the College was brought to the greatest straits. In consequence of the heavy taxes imposed, and the other exactions made, it became unable for a time to pay its rent to the Dean and Chapter of St. Paul's. To add to its distress, its premises were now condemned, as part of the property of the Church, to be sold by public auction. One

of our Fellows, Dr. Hamey, whose name deserves to be ever remembered, became however their purchaser, and afterwards gave them to his colleagues. Harvey himself contributed munificently to the substantial welfare of the College. A few years before his death "the Fellows," we are told "attended at the College when the doors were thrown open, and Harvey, receiving his assembled colleagues in the new museum, made over to them on the spot the title-deeds and his whole interest in the building," which, says Aubrey, was a noble building of Roman architecture, containing "a great parlour, a kind of convocation room for the Fellows to meet in below, and a library above." This gift preceded that of his patrimonial estate with which the establishment of this oration is connected. From these particulars, drawn from that excellent work, the "College Roll," from the pen of our esteemed colleague Dr. Munk, it is brought home to us how vastly altered the position of the College now is ; and I think I shall stand in accord with the opinion of others when I say that I consider the best kind of benefaction that

can be in the present age bestowed is such as I have had to commemorate to-day—one that confers upon the College the power of contributing towards making us, through the acquisition of increased knowledge, more efficient agents in the exercise of our calling.

The next part of my duty is to exhort the Fellows and Members of this College “to search and study out the secrets of nature by way of experiment.” These are the directions I am to follow, and they give me a wide field to select a course of procedure from. The kind of exhortation I shall employ will consist in placing before you a view of the method of work which Harvey himself adopted, and then, as an incentive to follow his example, I will display some of the fruit yielded by recent research conducted upon the lines of his procedure.

The object to be promoted is the acquirement of additional knowledge. . It is an old but true saying that knowledge is power. We accept the doctrine which comes to us in definite shape from no less ancient an authority than Aristotle, that there is

no such thing as innate knowledge, that knowledge of every kind has to be acquired, and that it is based upon perceptions reaching the mind through the senses.

Harvey thus epitomises what was said by Aristotle respecting the manner in which the knowledge appertaining to science is acquired—"The thing perceived by sense remains ; from the permanence of the thing perceived results memory ; from multiplied memory, experience ; and from experience, universal reason, definitions, and maxims or common axioms."

In its elementary form, knowledge consists of simple inferences drawn in a direct manner from impressions. A child once burnt afterwards shuns the fire. From the impression received an inference is framed which forms the foundation for future action.

The same kind of operation determines the conduct of the lower animals. By mental action these simple inferences may be raised into or give rise to knowledge of a higher kind. This is what for science is required to be done. The exercise

of the intellectual faculties must be brought into operation, in order that what we acquire through perception may be shaped into the knowledge that it is desired to obtain. The object in science is to discover the facts and laws of nature ; and to apply the intellect advantageously for the purpose there must be some systematic course, some method or art of reasoning adopted. The system employed up to Harvey's time was the Aristotelian, or syllogistic—a system which, whilst being well adapted for affording proof upon any particular point, is ill adapted for promoting the advance of knowledge. When through the major and minor premises of a syllogism I draw a conclusion, a point is proved, but no real addition is made to our stock of knowledge. For instance, when in accordance with the rules of the syllogistic art I say—

All men are mortal,
 Thomas is a man,
 therefore
 Thomas is mortal—

I start with the general proposition in the major

premise that "all men are mortal," and arrive at the conclusion, through the minor premise, that a particular individual is mortal. A certain attribute—mortality—is asserted to be possessed by a class. A member of the class must also possess the attribute, and this is all the information that my syllogistic conclusion has given me—that the individual, named Thomas, possesses the attribute of mortality, which belongs as a general character to the group of individuals of which he is a member. The two premises of the syllogism already consist of established truths, and for a syllogism to be valid there must be nothing contained in the conclusion beyond what is asserted in the premises. The train of reasoning, therefore, is not adapted to lead us to the acquirement of new knowledge. The essence, indeed, of the system consists in proceeding from generals to particulars. The major premise, with which we start, is, in reality, a general proposition, containing knowledge which has been acquired, not, it is true, by the methodical application of induction; but, nevertheless, after the manner of induction, by observation repeated and confirmed

until the thing has come to be accepted as an established truth.

Harvey was shrewd enough to perceive that such a system of reasoning, which had continued in use up to the period in which he lived, did not assist in the disclosure of the secrets of nature. He says, "The method of investigating truth commonly pursued at this time is to be held as erroneous and almost foolish, in which so many inquire what others have *said*, and omit to ask whether the things themselves be actually so or not; and single universal conclusions being deduced from several premises, and analogies being thence shaped out, we have frequently mere verisimilitudes handed down to us instead of positive truths."

Men's minds must have evidently now become occupied with the new system of philosophy set forth by Lord Bacon, in his "*Novum Organum*," or "true directions concerning the interpretation of Nature." One of the aphorisms of this work clearly exhibits the difference between the new system and the old.

“ There are and can be only two ways of searching into and discovering truth. The one flies from the senses and particulars to the most general axioms, and from these principles, the truth of which it takes for settled and immoveable, proceeds to judgment and to the discovery of middle axioms. The other derives axioms from the senses and particulars, rising by a gradual and unbroken ascent, so that it arrives at the most general axioms last of all.” Upon system, or plan of procedure, a great deal depends: look at any undertaking carried out under a good system and a bad. The ancients were a long time in learning the right system to adopt, but it was indeed a great day for science when the method of reasoning by induction was introduced. Starting with particulars or facts which are collected from nature by observation and experiment applied in every available way, it proceeds step by step in the process of generalizing until the largest and widest propositions are obtained. From the proposition which has been formulated out of, it may be, only a few facts, advance is made with the aid of other

facts to propositions of a more and more general character. The unknown is brought into the domain of the known, and as this domain increases, not only is the position acquired strengthened, but at the same time rendered more advantageous for the attainment of further extension. Thus the march onwards proceeds, and when some general law of nature—like, for instance, gravitation, the correlation of the physical forces, or, even, with a more limited bearing, reflex spinal action—is discovered, a gain is made which, through reflected influence, has the effect of at once immensely enlarging and perfecting the understanding. Truly, it may be said, the explorer by the inductive method does not know whither he may be led. He dedicates himself

“To unpathed waters—undreamed shores ;”

and follows simply the direction indicated to be taken by what happens to be revealed. Guided entirely by the facts disclosed by observation and experiment, he brings the instrumental agency of the mind as a reasoning power to bear upon them,

and draws from them that which adds to the store of knowledge already possessed. He seeks for facts, and interprets their meaning as they come before him.

This was the course pursued by Harvey. Instead of giving himself up, as others had done before him, to arguing out conclusions from accepted axioms, he struck out into the hitherto untrodden path of inquiry—that of induction—and sought knowledge by a direct appeal to nature through the medium of observation and experiment. “It were disgraceful,” he says, “with this most spacious and admirable realm of nature before us, did we take the reports of others upon trust, and go on coining crude problems out of these, and on them hanging knotty and captious and petty disputations. Nature is herself to be addressed, the paths she shows us are to be boldly trodden.”

In the discovery of the circulation Harvey applied the principles of induction and argued upon them in a strictly logical way. He showed himself to be a good and careful observer, judged even by the

standard set forth in the following words of John Stuart Mill on the process of observing:—"The observer," says Mill, "is not he who merely sees the thing which is before his eyes, but he who sees what parts that thing is composed of. To do this well is a rare talent. One person, from inattention, or attending only in the wrong place, overlooks half of what he sees. Another sets down much more than he sees, confounding it with what he imagines, or with what he infers. Another takes note of the *kind* of all the circumstances, but being inexpert in estimating their degree, leaves the quantity of each vague and uncertain. Another sees, indeed, the whole, but makes such an awkward division of it into parts, throwing things into one mass which require to be separated, and separating others which might more conveniently be considered as one, that the result is much the same, sometimes even worse, than if no analysis had been attempted at all. It would be possible to point out what qualities of mind, and modes of mental culture, fit a person for being a good observer: that, however, is a question not of logic, but of the theory

of education, in the most enlarged sense of the term."

The experiments which Harvey conducted on the arteries and veins, to assist him in his inquiry, were founded upon a well-devised plan. It may be said of experiment that it affords the means of varying the circumstances, and thus aids immensely the acquirement of knowledge by induction. In the application of the faculties to discovery, the mind asks itself what facts are needed to assist in the establishment of a correct conclusion. The fact may be looked for amongst the varied instances presented by nature; or, by an artificial arrangement of circumstances, the required instance may be made,—in other words, experiment may be had recourse to for supplying what is wanted. In the one case we get our fact by observation from the variations in the circumstances spontaneously furnished by nature; in the other we obtain it from experiment, which possesses the great advantage over observation, not only of furnishing us with a much greater number of variations than is to be found naturally presented, but also of enabling us

to produce the precise form of combination or variation which is needed for our purpose.

Harvey in a true sense adopted the Baconian system of interrogating nature by appeal to observation and experiment and drawing conclusions out of the facts presented, and yet it is evident that the "Novum Organum" was not published till after the discovery of the circulation was made. Bacon's new method of conducting research and discovering the truths of nature was placed before the public in 1620. Harvey's work on the circulation, "*Exercitatio anatomica de motu cordis et sanguinis animalibus*," was not published till 1628, but it has been generally allowed that his discovery was made known in his first course of Lumleian lectures delivered at the College in 1616; and, thanks to the meritorious labours of a Committee of the College, this has now been rendered open to verification by the very interesting volume just prepared, and on the point of being issued, containing a reproduction in autotype form of his original lecture notes in his own handwriting. Harvey, then, must have been thoroughly in the van of progress taking place in

his day ; and, further, the contemporaries of Bacon must have been acquainted with the new system of philosophy before the "Novum Organum" was published.

Harvey's discovery established a new departure in physiology. Without a knowledge of the circulation nothing really could be known about the various operations taking place within us. It is hard, with the knowledge now possessed, to realise the state existing at the time the circulation was discovered. The passage of blood from the right to the left side of the heart had, it is true, already been recognised, but it was taught that the blood went to the lungs for their nutrition, and "to be elaborated and subtilised by the reception of a spirit from the air in inspiration and the exhalation of a fuliginous matter in expiration." The heart and arteries were supposed to be the seat of the vital spirit, and the liver to be the fountain from whence the body was supplied with blood through the veins, in which there was believed to be a to-and-fro current—a flux and reflux, that was compared to the ebb and flow of the tide in the

classic straits of Euripus. Truly, indeed, may it be asserted that our ancestors stand in the twofold position of our parents with respect to age, our children with respect to knowledge.

It was not without opposition that Harvey's views were received ; and the high position in his profession he had attained did not suffice to prevent his escape from the effect of the prejudice against innovation entertained by the multitude. Aubrey tells us he had "heard him say that after his book on the circulation of the blood came out he fell mightily in his practice ; 'twas believed by the vulgar that he was crack-brained, and all the physitians were against him." Harvey lived, however, to see his doctrine generally accepted. But, such are the vicissitudes of time, that in our day an attempt has been made to deprive him of the title of discoverer of the circulation and give it to an Italian physician, Cesalpino, because it has been found that a few words of what he wrote can be construed into suggesting that a conception of the circulation existed in his mind. Most ably and successfully have my predecessors in the delivery

of this oration, Sir Edward Sieveking and Dr. George Johnson, combatted the claim that has been put forward on behalf of Cesalpino, and maintained the position of Harvey.

Science prepares the ground for the exercise of art. The one—science—is concerned with knowledge as knowledge; the other, with the application of it to a practical end. Our art—our *raison d'être* as members of the medical profession—is to apply the knowledge of medical science to the prevention of, cure or mitigation of, and alleviation of the sufferings from, disease—to secure, in fact, for man as natural a passage through life as happens to be attainable. We cannot prevent death. Lord Bacon, in his essay “De Morte,” said—

“Æque enim est naturale hominibus mori, ac nasci.”

True—it is as natural to die as to be born; and, nature's laws must be complied with. Our aim is to avert premature death. A certain power, given to us at starting upon our existence, carries us on, under exposure to the proper conditions or influences for keeping this power going. But, in the

exercise of its action, although for awhile it shows no signs of a failing tendency, yet assuredly it progresses towards exhaustion and ultimate extinction. Accompanying, and doubtless dependent on, the declining power, and assisting in leading to its becoming extinguished, there is an advancing deterioration of the material organism in which the power is manifested. Such is what is natural, but many circumstances contribute to avert the natural—the ordinary course being run. The power given to start with may not be equal to the standard, and the issue of generation may in consequence present itself under a weak and ill-developed form, easily falling a victim to influences that there ought to be strength enough to resist. There may be a taint in the power derived by generation from the parents—something transmitted by inheritance which may give rise to a tendency to the development of some structural deviation from the natural state or to the performance of one or other functional operation of life in a manner that does not conform with what may be said to be strictly natural. It is a law of nature for the offspring more

or less closely to assume the likeness of the parent, and likeness in the shape of what is wrong may be assumed as well as in the shape of what is right.

Quitting the quality of the power given to us to start with, we are next dependent upon the influences derived from the external or surrounding conditions to which we become exposed. Light, air, what we eat and drink or what in any way gets into the system, temperature, exercise of mind and body—in short, the conditions under which we live—all exert their influence in favouring or otherwise a natural passage through life. Within us, operations forming a part of the operations of nature proceed, but these operations are influenced by—owe their activity indeed—to the surrounding conditions, and thus it is that upon these surrounding conditions depends whether a natural course is run or not. Under the same law these surrounding conditions may exert a modifying influence in this or that particular direction upon the operations that are proceeding, and by long continuance in force may lead to the establishment of a more or less modified state as a part of our nature

in accordance with the Darwinian principle of natural selection. This matter—the modifications for good or bad wrought in our nature by the influence of external conditions—embraces a wide field of study and comprehends nothing less than the possession of a knowledge of the varied operations, with the laws determining them, going on around us in order that we may understand the manner in which they are brought about. It is a vast subject, but the mind of man has already done much, and there is reason to think will do much more, towards penetrating it; and as with the amount of knowledge acquired power is possessed—that is, the power of arranging conditions or operations so as to render them subservient to the production of a desired effect, man stands in the position of an increasingly powerful agent in the realm of nature. Must not the mind itself, then, through which this is accomplished be reckoned as a power—a great power amongst the powers of the universe? In our special department as medical practitioners it falls to us to apply the power which knowledge gives us towards preventing unnatural

conditions of the body from being allowed to become developed, and towards bringing the unnatural back into the natural state—in fact, towards aiding in carrying life on in a natural manner through its ordinary term of existence. In every branch of study relating to our art immense progress has in recent years been made. It is true, all gain in knowledge must be regarded as contributing to the improvement of our position, but at the same time it is not permitted to us to see in each gain a direct applicability to a useful end. I will however refer to one issue of research derived from the labours of the present day which has already yielded much good and useful fruit and gives promise of yielding much more.

Belonging to the realm of living nature there are small organisms, the existence of which we must have remained unconscious of in the absence of the aid of the microscope. The organisms to which I refer are rod-like in form and of such minute dimensions as to require a good magnifying power to enable them to be brought into view, and some of them, also, to be rendered visible require to be

stained with a colouring agent. These bodies are known by the name of bacteria or bacilli, and, whilst some difference of opinion has existed, it is generally thought that they are organisms belonging to the vegetable kingdom. There is nothing in their appearance to strike the observer that they possess any significance, and yet by recent research it has been found that they play a most important part as constituents of the living world. The character from which they mainly derive importance is the facility and rapidity with which they become developed. This contributes to their wide distribution and counterbalances their minuteness.

It is only recently that the life of these organisms has been known to produce effects of any particular interest to us. Some while ago they gave rise to a discussion upon the subject of spontaneous generation which was carried on throughout several years with at times a considerable amount of warmth. The fact had been observed that when a liquid containing organic matter was exposed to the air, it more or less quickly, according to the prevailing temperature,

became tenanted with an immense number of these micro-organisms. The question arose whether they sprang into existence from the fortuitous concourse of disuniting atoms of the organic matter or whether they were derived by parentage from pre-existing organisms. Spallanzani, who lived in the eighteenth century, performed the experiment of placing the organic liquid in a vessel, hermetically sealing it, and afterwards exposing it to a temperature sufficient to destroy the life of any living matter present, and found that under these circumstances no organisms became developed. It was suggested that the presence of air might be a necessary condition for the re-arrangement of the elements of the organic substance into living matter, and through this being excluded in Spallanzani's experiment it might be thereby rendered fallacious. Schulze and Schwann came upon the field just about fifty years ago and devised an experiment which stands invested with historical renown. They placed the organic liquid in a flask and boiled it to effect the destruction of any life that might exist. The flask was closed

but provided with tubes, through which air could be made to reach the interior, and, as the essential part of the experiment, the air thus made to enter was transmitted either through sulphuric acid or a heated tube for the purpose of killing anything of a living nature that might happen to be present. Thus circumstanced, and under the frequent renewal of air in contact with its surface, the liquid remained for any length of time free from living organisms, but when the mouth of the flask was unclosed and its contents were freely exposed to the air they were soon found to be swarming with living beings. The natural conclusion to be drawn from such an experiment is that it goes far towards absolutely establishing that the air contains the germs of living organisms and that it is these that constitute the source of the microscopic organisms found to become developed in the presence of organic matter, which some have contended take rise spontaneously. This view is supported by the researches of the present day and nothing that would bear the scrutiny of strict investigation has ever been adduced against it. It stands at the

foundation of our modern notions regarding the *rôle* played by bacilli and thus occupies a position of weighty importance with reference to the matter.

Both upon dead and living organic matter these organisms exert an influence productive of wide and strikingly marked results. Although known to become developed in decaying animal and vegetable infusions it was not until recently suspected that they stood in any other relation than as a simple growth in a suitable medium—certainly it was not suspected that they held the position that is now assigned to them. Whilst life exists in any particular being there is a round of actions carried on—a round of changes occurring in a definite and fixed direction giving rise to the phenomena that are observed. When death occurs another set of changes is seen to set in. The affinities and operations formerly in play, which held the elements together in specific combinations and led to the occurrence of a specific line of changes, ceasing to prevail, the conditions become free for new affinities to come into force and produce new combinations, and with this for a new

line of changes to occur. Such was until recently looked upon as furnishing a representation enabling us to understand the *rationale* of the passage of a substance into a state of putrefaction. Instead, however, of regarding the elements of organic compounds as simply splitting asunder as a result of the removal of the influence of life to form others generated by new affinities starting into existence after death, we are brought by the evidence now before us to look upon putrefaction as the issue of the influence exerted by the living organisms, to which our attention is being given.

However much, viewed superficially, the process may appear to arise from spontaneous disintegration, no such disintegration takes place unless there is the necessary agency present to excite it, and this agency consists of living organisms comparable in the effect they produce to the living cells of yeast which have the power of exciting the transformation of sugar by what is styled fermentation. It is only then in the presence of the organisms in question that putrefactive decomposition occurs. Exclude them in any way that

may be chosen and the organic product, whether milk or any other article, remains without undergoing change.

The step from the action exerted by bacteria as agents exciting the decomposition of organic products to that which brings them before us as a source of disease is not a great one. In the one case they lead to change which would not otherwise occur, and in the other they disturb the order of changes naturally taking place and thus induce an abnormal state ; and although there is nothing in their morphological characters to show the reason, different trains of phenomena—in other words different diseases—are occasioned by different kinds of bacilli.

It is in the group of disorders falling under the denomination of contagious or infectious febrile diseases, a form of disease taken in its entirety constituting one of the greatest scourges besetting the human race, that we are brought most manifestly into contact with bacilli. Very diverse views have been held at different times regarding the nature and mode of production of the affections belonging

to the class in question, but by recent research it may be considered as having been rendered evident that they depend upon the introduction of bacilli into the system, to the growth and multiplication of which are due the phenomena that are observed. Opinion has for some time past been advancing to this point. Our countryman Dr. William Budd devoted special attention to cholera and typhoid fever and in 1849 stood prominently forward in urging that a living microscopic organism constituted the source of the diseases of their kind. For awhile, however, fever germs were only talked about, without their reality being regarded as established. The discussion at the Pathological Society in 1875 on the germ theory of disease marks an epoch in the history of this subject, and shows that up to this time much progress had not been made towards settling the question ; for, whilst some spoke in favour of the theory, no less an authority upon fevers than the late Dr. Murchison expressed himself strongly against it. Since then, knowledge has advanced in great strides ; and, now, not only has the fact

been ascertained that different kinds of organism productive of different diseases exist, but through the indefatigable researches of Pasteur and others the distinguishing form and life history of certain of these organisms have been clearly made out. Placed under suitable conditions, it has been found that they can be reared or cultivated artificially, and one of the most marked and important characters belonging to them is the enormous extent of self-propagating power they possess. This accounts for the rapid spread that is observed to take place of an infectious disease, if allowed to progress without controlling measures being brought to bear upon it.

We have to deal, then, with something that lives and grows by virtue of a power pertaining to itself. Permit this living growth—this parasite in fact—to become dispersed and to enter the system of a living person, and presuming it has lodged upon a soil supplying suitable conditions for its development, it will thrive and multiply and give rise to a series of phenomena, which the physician has no power to arrest. Once the

bacillus implanted and the disease established, all that the physician can do is to see that the patient has fair play—that he is kept under the most favourable conditions for battling successfully against his enemy. What is to be philosophically aimed at, however, is to check the spread—to bar the transmission of the parasite from one person to another by attacking it outside the body; and this, with the application of the proper measures of disinfection, can with facility be done, but naturally the facility of preventing extension stands in proportion to the degree of limitation at the time existing. The spark of fire is with the greatest ease extinguished, but let it kindle into flame, and in proportion as the flame spreads the difficulty becomes greater to get the conflagration under.

This is one way in which the attack upon the bacillus may be made, and the ravages of disease restrained. Another way, by quite a different line of tactics, presents itself; and the knowledge of this is due to the researches that have been recently conducted. The vulnerable point to which

I am alluding lies not in connection with the bacillus itself, but with the condition of the medium upon which it may chance to fall. It has been found that the parasite requires virgin soil for its growth. This observation stands in harmony with the result of common experience as regards disposition to contract infectious disease. It has been from remote times generally known that a person who has passed through one attack of an infectious disorder is not liable to the same extent as before to become affected on exposure to contagion. An influence has been exerted giving rise to more or less protection being afforded against a recurrence of the disease. Now, it happens that by certain means the bacillus may be brought into such a weakened state as only to occasion, when introduced into the system of an animal, an effect of a mild nature, not dangerous to life, instead of the ordinary form of disease ; but the effect produced, and this is the great point of practical importance, is as protective against a subsequent attack as the fully developed disease.

There are two methods by which attenuation

in virulence of the disease-producing organism may be brought about—by conducting their artificial cultivation in a particular way, and by transmission through the system of an animal differing in nature from that in which the disease naturally occurs.

When the chain of discoveries reached the point of showing that bacilli could be reared outside the body in an artificial soil or cultivating medium, a great advance was made towards obtaining a full knowledge about them, as it placed the observer in a more favourable position for the successful prosecution of research by enabling him to vary and control his conditions in a manner that could not otherwise have been effected. Although much has been accomplished, it must be said much still remains to be done. In the case of a few bacilli the life history has been pretty clearly made out. Cultivated in a certain way they retain their virulence, no matter through how many successions they pass. The last product in a series of successive cultivations is as virulent as the parent stock. By modifying the conditions under which

the cultivation is carried on, the successive products of descent may be gradually weakened until they become harmless. Such being the case, any desired degree of attenuation may be obtained, and by inoculation with a virus brought down to the proper strength the non-fatal affection may be occasioned which gives immunity from subsequent liability to take the disease under exposure to contagion. The knowledge thus acquired has been already practically turned to account upon a large scale for checking the ravages of that exceedingly fatal disease amongst cattle known as anthrax, or splenic fever, and through the success attained much sacrifice of life has been averted.

If this can be accomplished for one disease, and more than one can be mentioned, is there not ground for believing that means will be found for placing others of the class in the same position? Attempts are being made in this direction. All eyes throughout the civilized world are, indeed, at the present moment fixed upon the work of Pasteur in Paris with reference to hydrophobia. It would be a great achievement for this

frightful disease to be brought under subjection, and certainly the results that have been obtained appear to give hopes that an approach to something of this kind has been arrived at. Looking at the nature of the disease there is nothing inconsistent with its being dependent upon a bacillus, or microbe, as Pasteur calls it. On the contrary, owing its origin as it does, when occurring naturally, to inoculation with the poisoned secretion of an affected animal, and taking into view the facts that have been learnt in connection with its transmission by artificial inoculation, evidence points to such in reality being the case. If due to a bacillus, why may not this bacillus be open to attenuation in the same manner as that of anthrax? if thus open to attenuation, why not susceptible of producing a non-fatal form of affection? and if this condition has been produced and passed through, why should not protection be thereby given against the subsequent development of the disease as a result of the primary inoculation from the bite of the rabid animal? Such a train of reasoning is quite legitimate, and

for the application of the principle of action to which it leads, there is this advantage on the side of hydrophobia, that from the prolonged period usually taken for incubation after the introduction of the poison in the ordinary way, time is given for the artificial inoculations by subcutaneous injection to produce their effect and to render the system refractory to the further development of disease. I have been an eye-witness of Pasteur's work. It is from the nerve centre, the seat from which the symptoms of the disease start, that he obtains his virus. Employed for inoculation in a fresh state it produces a fatal disease, and the disease has been transmitted successively on through a number of animals with the result that the last affected animal yields as strong a virus as the first. Kept in a pure dry air, attenuation advances, and after a certain time the nerve centre loses its disease-producing power. Used for inoculation at a given period of preservation it produces an effect which renders an animal resistant to the influence of inoculation with the virus in a fresh state, and Pasteur contends that it acts similarly

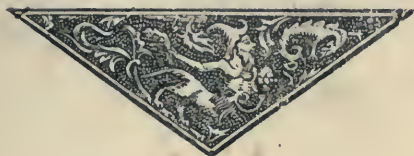
when the virus has been introduced in the ordinary way. The treatment of persons bitten by rabid animals by inoculation with attenuated virus, has now been on its trial a considerable time, and a large experience gained. Judgment, it must be stated, still stands in suspense ; but it must also be said that the results obtained tell decidedly in favour of the view advanced.

The other method by which it has been recently experimentally found that the virulence of bacilli can be weakened is by transmission through an animal of a different nature from that in which the disease naturally occurs. This, in reality, represents the principle at the foundation of the system of vaccination, discovered by Jenner at the close of the last century. It may now be regarded as an accepted conclusion that vaccine-lymph is the virus of small-pox, modified by transmission through the cow. Jenner's discovery consisted in showing that the result of vaccination with the lymph of cow-pox affords as much protection against small-pox as an attack of small-pox itself. This was the fact he deduced, but the knowledge

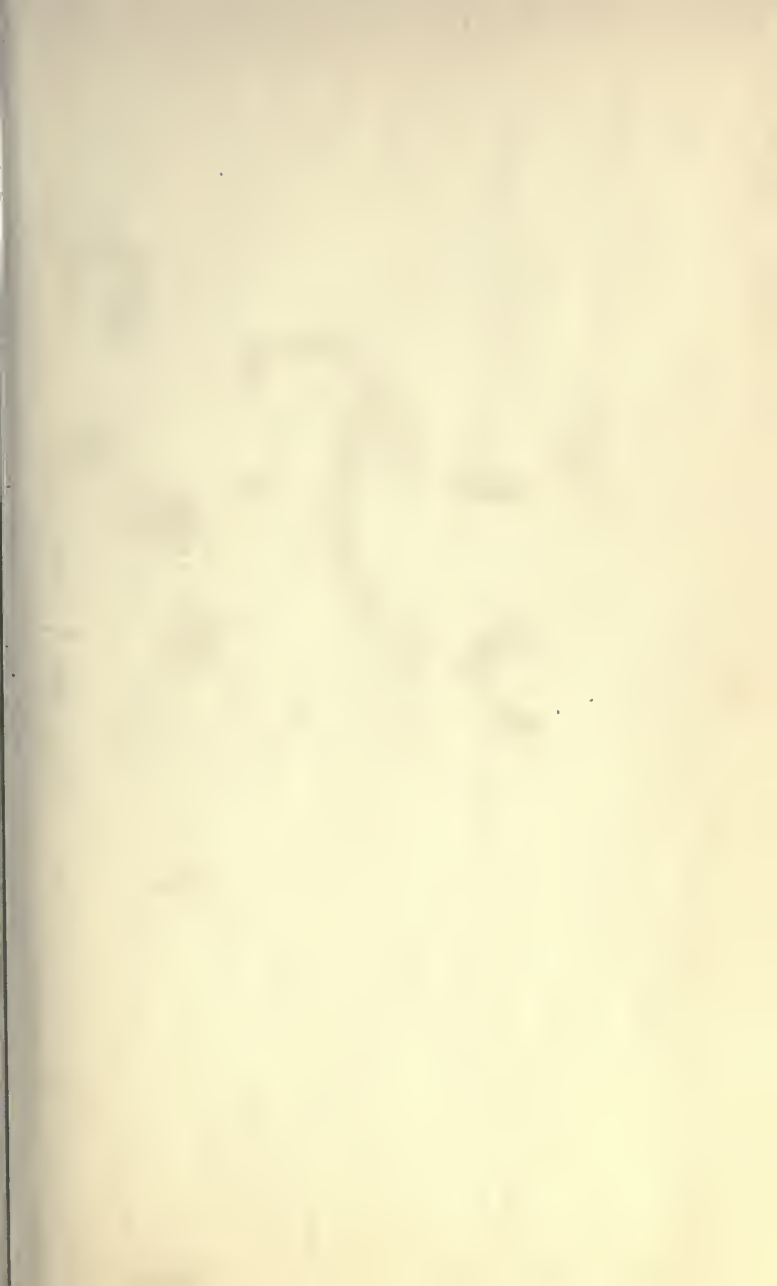
possessed in his time did not permit of its being looked at in any further way than as a simple fact or truth of nature. Viewed, however, with the light that has been thrown upon it by the researches of the present day, we see not only the fact, but also its explanation—we see that the principle of action of the procedure proposed by Jenner, which has conferred such incalculable benefit upon mankind, is based upon the attenuating effect upon the small-pox virus of the human species by transmission through another animal, and knowing this the prospect is presented of its being rendered susceptible of application for the control of other diseases. Whether this should prove so or not, at all events, advantage is gained by the knowledge acquired.

Need I say anything more to exhort you in accordance with the duty that has devolved upon me? Surely the acquirement of knowledge, giving us as it does greater power in the exercise of our calling, and thereby promoting the high and noble object of rendering our lives more useful to our fellow-creatures—surely this is a sufficient in-

centive, following the words of Harvey, "to search and study out the Secrets of Nature by way of experiment."



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